Name of Organization: SUNY Research Foundation/Buffalo State College

Type of Organization: College or University

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Project Title: Erosion/Transport of Contaminated Sediments by Ship Traffic

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 0

Total Funding Requested ($): 68,242 **Project Duration:** 1 Years

Abstract:

The Buffalo River near its mouth is a Great Lakes Area of Concern characterized by heavy industrial development in the midst of a large municipality, and it has long been the receiving water for contaminants from a variety of food processing, chemical, metallurgical, and petroleum industries. The Buffalo River: (1) is used for fishing, swimming, and boating, especially by the urban poor of Buffalo; (2) discharges into Lake Erie within 1 km of the water intake for the City of Buffalo Water Authority; (3) is the focus for an aggessive program of habitat restoration at several designated nature preserves; and (4) is the proposed site for a major urban revitalization program. All of these functions can be compromised during resuspension events when contaminants are reentrained in the water column, and the reentrained contaminants could also be released to Lake Erie and the Niagara River (and, thus, to Lake Ontario). We propose to assess the potential for deep-keeled ships to resuspend and entrain plumes of contaminated sediments from the bed of the Buffalo River. We will track the plume using Seabird SBE 25 Sealogger profilers, and we will use EVS-PRO software to develop 3-dimensional visualization models of the plume and its surrounding water mass. From this data we will develop models that will show: (1) the extent of the sediment resuspension; (2) the transport pathway taken by the suspended sediment; and (3) its ultimate fate.

Geographic Areas Affected by the Project

States:

- ☐ Illinois
- ☐ Indiana
- ☐ Michigan
- ☐ Minnesota
- ☒ New York
- ☐ Pennsylvania
- ☐ Wisconsin
- ☐ Ohio

Lakes:

- ☐ Superior
- ☐ Huron
- ☐ Michigan
- ☒ Erie
- ☒ Ontario
- ☐ All Lakes

Geographic Initiatives:

☐ Greater Chicago ☐ NE Ohio ☐ NW Indiana ☐ SE Michigan ☐ Lake St. Clair

Primary Affected Area of Concern: Buffalo River, NY

Other Affected Areas of Concern: Niagara River/Lake Ontario

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

Harbors around the Great Lakes historically have been the principal repositories of the waste products of human activities. Most of these contaminants are concentrated in bed sediments where they are adsorbed onto sediment particles, altered by biochemical processes, and stored, at least temporarily. Especially serious are problems in harbors that contain fine sediments because their high surface-to-volume ratio increases their potential to absorb dissolved pollutants and because they are susceptible to erosion and resuspension. Resuspension and erosion of contaminated sedimentary material and subsequent transport to more pristine areas results in dispersal of pollutants over a much wider region than was initially affected. Because of this, highly polluted bed sediment layers may represent a source that can be an order of magnitude larger than incoming pollutants entering a stream at its upstream or lateral boundaries. To predict the migration of pollutants in a stream or river, therefore, it is important to understand not only their primary modes of transport and dispersion, but also secondary modes due to erosion and resuspension of contaminated sediments.

Release of contaminants from harbor substrates into the water column can be accomplished through diffusion from resuspended particles and release of interstitial pore water that may have come into equilibrium with sediment particles during residence in the bed. In order to estimate the potential for contaminants stored in bed sediments of Great Lakes harbors to enter the water column and be transported lakeward, we must have a better understanding of the capacity of waves, unidirectional currents, and passage of ships to: (1) generate bottom shear, (2) erode flocculated sediments, (2) resuspend them in the water column, and (4) move them lakeward.

The Buffalo River near its mouth is a Great Lakes Area of Concern characterized by heavy industrial development in the midst of a large municipality, and it has long been the receiving water for contaminants from a variety of food processing, chemical, metallurgical, and petroleum industries. Much of the industry has left the area, and the remaining industry has reduced contaminant discharge greatly. However, chemical analyses of sediment from the Buffalo River indicate the presence of a variety of contaminants including toxic organic compounds, heavy metals, and pathogenic microbes. Despite these problems, the Buffalo River: (1) is used for fishing, swimming, and boating, especially by the urban poor of Buffalo; (2) discharges into Lake Erie within 1 km of the water intake for the City of Buffalo Water Authority; (3) is the focus for an aggessive program of habitat restoration at several designated nature preserves; and (4) is the proposed site for a major urban revitalization program. All of these functions will be compromised during resuspension events when contaminants are reentrained in the water column.

In addition, reentrained contaminants could be released to Lake Erie and the Niagara River (and, thus, to Lake Ontario), but the contribution of the Buffalo River to the chemistry and hydrology of Lakes Erie and Ontario and the Niagara River is uncertain. The Lake Management Plan (LaMP) for Lake Erie includes the Buffalo River in the drainage basin for Lake Erie. However, it also is considered a tributary of the Niagara River for purposes of mass balance modeling as part of the Lake Ontario LaMP, even though the Buffalo River watershed is not included in the drainage basin of Lake Ontario, and the river itself is a Great Lakes Area of Concern,. In addition, the Buffalo River is considered a tributary of the Niagara River in the Remedial Action Plan (RAP) for the Niagara River AOC. Whether or not mixing occurs is critical to mass balance

studies in the two lakes and the Niagara River, and the loadings from the Buffalo River must be correctly apportioned among the waterbodies in order to correctly assess the potential benefits of various remediation efforts on their water quality.

Proposed Work Outcome:

The hydrology of the Buffalo River was radically altered when the lower part of Buffalo Creek was widened and dredged. Except during storm events, downstream flow is normally too slow to generate significant shear stress on the substrate, but waves and seiches can generate the shear needed to resuspend sediment. One of us (Irvine) has also shown that deep-keeled ships can cause erosion of the bed sediments in the Buffalo River and Hamilton Harbor, another Great Lakes AOC. However, only limited 3-dimensional control was possible in these studies, and no effort was made to track the plume to determine its ultimate fate, nor to sample the water bodies in three dimensions to determine the extent and duration of the suspension. We propose to assess the potential for ship passage to resuspend and entrain plumes of contaminated sediments from the bed of the Buffalo River, and we also propose to track the plume into the receiving waters of Lake Erie and the Niagara River. To do this we will analyze the water column in the Buffalo River, Lake Erie, and the Niagara River before, during, and after the passage of a deep-keeled, bulk cargo carrier during a spring flood event in the Buffalo River and during quasi-base flow conditions in the fall. We will track the suspended sediment plume as it traverses the Buffalo River and enters Lake Erie and the Niagara River, and we will develop 3-dimensional visualization models of the plume and its surrounding water mass. From this data we will develop models that will show: (1) the extent of the sediment resuspension; (2) the transport pathway taken by the suspended sediment; and (3) its ultimate fate.

Closely-spaced sampling is required for the analytical procedures we will use, and it is feasible to attain a high density using the equipment available for the project. We will use Seabird SBE 25 Sealogger profilers to collect the large amounts of data needed to parameterize the plume. These loggers will be used because their capability for continuous analysis allows for rapid deployment and recovery at each sampling station. In a recently conducted feasibility trial using a single logger, we occupied 147 sites in eastern Lake Erie over a 3.5-day period, logging to depths in excess of 60 meters.

Monitoring will take place along a minimum of 20 transects using three vessels, each deploying one of the loggers. X,y positioning will be done with Magellan GPS units, and z locations will be established by pressure transducers on the profilers supplemented by depth recorders on the winch cables. Parameters measured will include conductivity, depth, temperature, Eh, pH, dissolved oxygen, turbidity, and chlorophyll content, although turbidity will be the most useful of these in establishing the shape and movement of the plume. The CTD data loggers will collect information on all parameters at 0.50 sec intervals; data reduction will convert this to 0.25 meter depth intervals.

These data will be entered into EVS-PRO software for 3-dimensional visualization and analysis. The software will allow us to view the spatial relationships between the suspended sediment and the surrounding water in the three water bodies and to analyze spatial variability of the measured parameters in three dimensions. This software combines state-of-the-art analysis and visualization tools into an extremely powerful system that can be integrated with modular analysis and graphics routines such as ArcInfo and ArcView for customized visualization applications. EVS -PRO is capable of accepting digital data from the Seabird logger and processing it for display as fully-bounded and color-mapped 3D isovolumes and 3D colored isolines, exploded layers of selected value intervals, interactively positioned horizontal and vertical slice planes, configurable 3D labeled axes, and rectilinear or offset convex hull-bounded griddings. All views are capable of rotation and translation in real-time in order to achieve optimum viewing perspectives. Indicator krigging and heterogeneous parameter modeling will be used to correlate between discrete data locations to view three-dimensional spatial variability and to perform volumetric analysis.

The final product of the research will be 3-dimensional visualization models of the plumes of contaminated sediments raised by the passage of cargo carriers during two periods of significantly different hydraulic conditions in the river. These visualkizations will show the body of suspended sediment, its relationship to the enclosing waters, and internal variation in character in the Buffalo River, as it leaves the mouth and transits Lake Erie, and as it begins its flow down the Niagara River. Special attention will be paid to the boundaries of the flow so that estimates of the degree of mixing during the life of the plume can be made. This work will result, not only in providing estimates of the potential for resuspension of bottom sediments by passing ships in the Buffalo River, but also data concerning the fate of the plume of the Buffalo River as it enters Lake Erie and the Niagara River.

Project Milestones:	**Dates:**
Project Start	09/2000
Sampling during base flow	11/2000
Data reduction, 3-D visualizations	02/2001
Sampling during flood flow	05/2001
Data reduction, 3-D visualizations	07/2001
Final Report	09/2001
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Project End	09/2001

☒ Project Addresses Environmental Justice

If So, Description of How:

The Buffalo River is extensively used for recreation by the urban poor of Buffalo. It is used for swimming, boating, and stream side activities, and it is considered an important source of food by members of that demographic group. In fact, the potential toxicological effects of fish consumption from the river by the urban poor of Buffalo has been the subject of studies in the past. The water quality of the river is poor for such factors as iron content, dissolved oxygen, and fecal bacteria, and reentrainment of contaminated sediments can only exaccerbate the situation with respect to heavy metals and organic compounds, with subsequent impact on game fish in the river.

☐ Project Addresses Education/Outreach

If So, Description of How:

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	28,949	6,725
Fringe:	2,902	1,961
Travel:	1,000	0
Equipment:	9,500	0
Supplies:	1,000	0
Contracts:	0	0
Construction:	0	0
Other:	2,600	7,700
Total Direct Costs:	45,951	16,386
Indirect Costs:	22,291	7,488
Total:	68,242	23,874
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

Description of Collaboration/Community Based Support:

This project is part of a long-range effort in collaboration with several local agencies to assess the impacts of a variety of factors on the water quality in the Buffalo River. We have, over the last decade, worked closely with the Buffalo Sewer Authority, Erie County Department of Environment and Planning, and the USEPA to develop the baseline information needed for the Remedial Action Plan for the Buffalo River. Special emphasis has been placed on understanding the impact of storm flows on the water quality in the river, and this project will extend that with information on the impact of ship passage.